MDU Solar Energy Project Case Study

A Partnership between Ellsworth AFB and MDU Resources Group, Inc.

MDU RESOURCES GROUP, INC.

- Based in Bismarck, North Dakota
- Celebrated our 85th year in 2009
- NYSE - MDU for over 60 years
- Over $4B market cap
- Fortune 500 Company
- Member of the S&P MidCap 400 Index
- Over 8,000 employees in 44 states

MDU RESOURCES
GROUP, INC.

- <u>Business Lines:</u>
  - Energy
  - Utility Resources
  - Construction Materials

MDU RESOURCES GROUP, INC.

- Construction Materials
- Energy
  - Oil and Gas Production
- Utility Resources
  - Natural Gas Pipelines
  - Construction Services
  - Electric / Natural Gas Utilities

MDU RESOURCES GROUP, INC.

- Utility Resources
  - Montana – Dakota Utilities Co.
  - Cascade Natural Gas Co.
  - Intermountain Gas Corporation
  - Great Plains Natural Gas Co.
    - About 950,000 customers
    - ND, SD, WY, MT, WA, OR, ID, MN
  - Bitter Creek Pipelines, LLC
    - Non-Regulated sister company

PARTNERSHIP …

- Ellsworth – Montana Dakota Utilities Co. Service Area
- Ellsworth AFB and the MDU Resources Group, Inc. have a well developed partnership having completed numerous projects over the past decade
  - Propane Air Mix Plant / Expansion
  - Two UESC Task Orders
  - Advance Metering Initiative
  - New UESC Task Order #3
  - Solar Energy Project

Ellsworth Air Force Base

Rapid City Army Air Base

Completed 20 September 1942

Historical Perspective

Utilities office personnel check EAFB thermostats

Offices at Ellsworth AFB are receiving visits from mysterious individuals, who check the office's thermostat and then start swinging a small metal device.

But the occupants soon discover there is no reason for alarm. The individuals are from the newly-formed utilities conservation office and they are seeing if the office or work area is in compliance with existing utility regulations and directives.

The small metal device is an ambient air temperature indicator, which gives the current temperature in a room. It may or may not correspond with the temperature registered on the thermostat, and that's the reason for the visit.

The utilities office was mandated by the base utilities management working group, headed by Col. William L. Shields Jr., base energy conservation officer.

According to 2nd Lt. James L. Nelson, an engineer assigned to the office, it was designed to

- Insure compliance with base utility conservation regulations through periodic inspections of all facilities.
- Identify those utility systems in need of repair or adjustment.
- Provide information to the base utilities management working group to measure effectiveness of their educational program.
- Take steps to repair, renovate or replace systems as required.

Nelson and S.Sgt. Patrick Kilmartin, or one of the other airmen assigned to the office are surveying all heated base facilities and electrical and lighting systems.

When discrepancies are found, three courses of action are taken. If the building is found to be not in compliance, and it was the willful disregard of directives or regulations on the part of the occupants, the utilities office feeds the information to Shields, who deals with it through the chain of command.

If the building is not in compliance, at no fault of the occupant, rather the system is defective, either it will be repaired "in house" by civil engineers or it will be added to future programs.

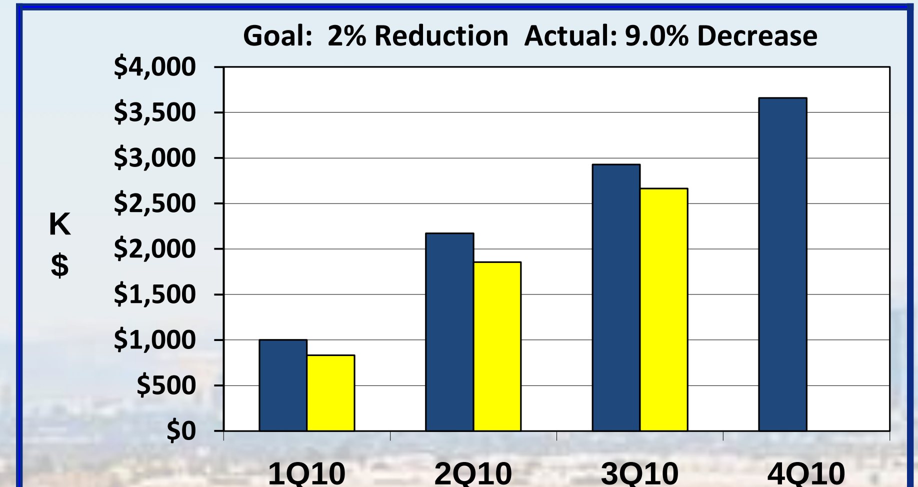
Nelson (left) and Kilmartin check a thermostat (Air Force photo) 17 Jan 74

"If the building is not in compliance and it is the willful disregard of the occupants, the utilities office feeds the information to Shields who deals with it through the chain of command." (EAFB Newspaper, January 1974)

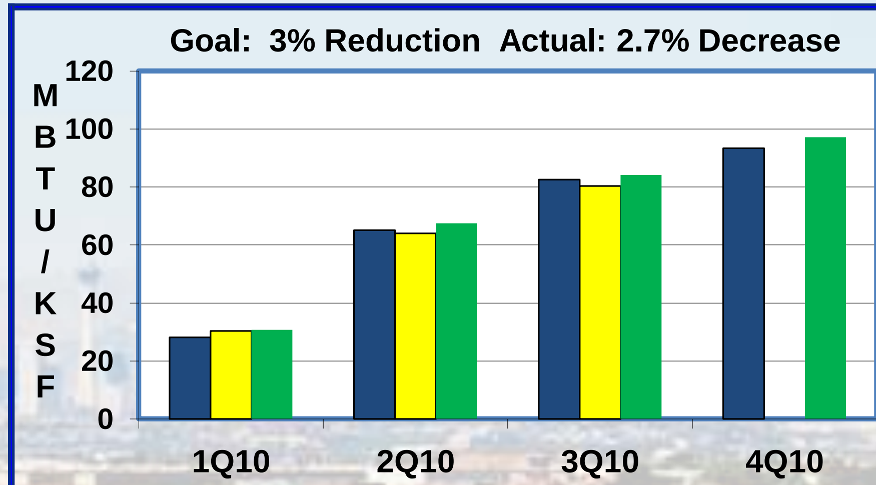
Brigadier general William L Shields retired in 1981 after a 35 year career.

ELS 3rd QTR 10 Energy Management

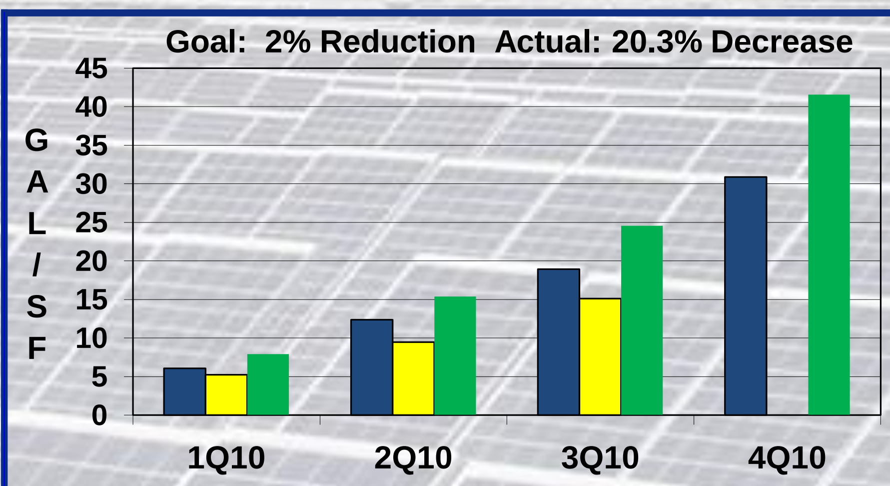
Utility FO Expenditures



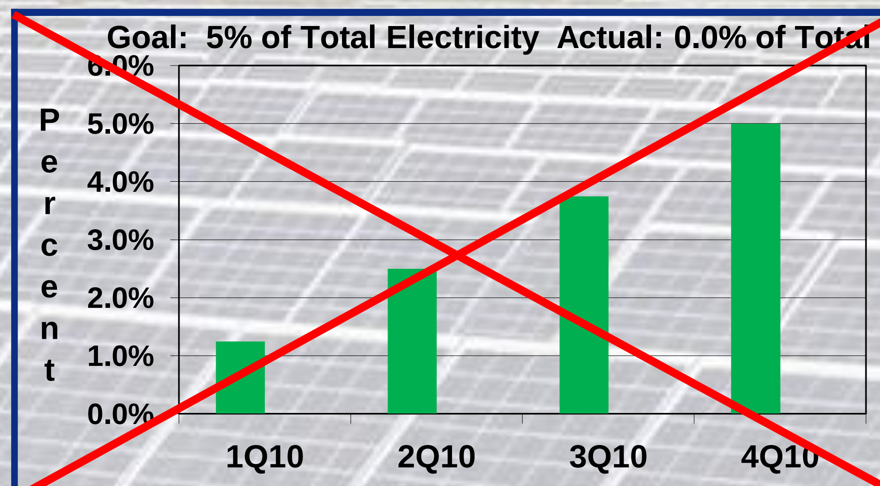
Energy Intensity



Water Consumption

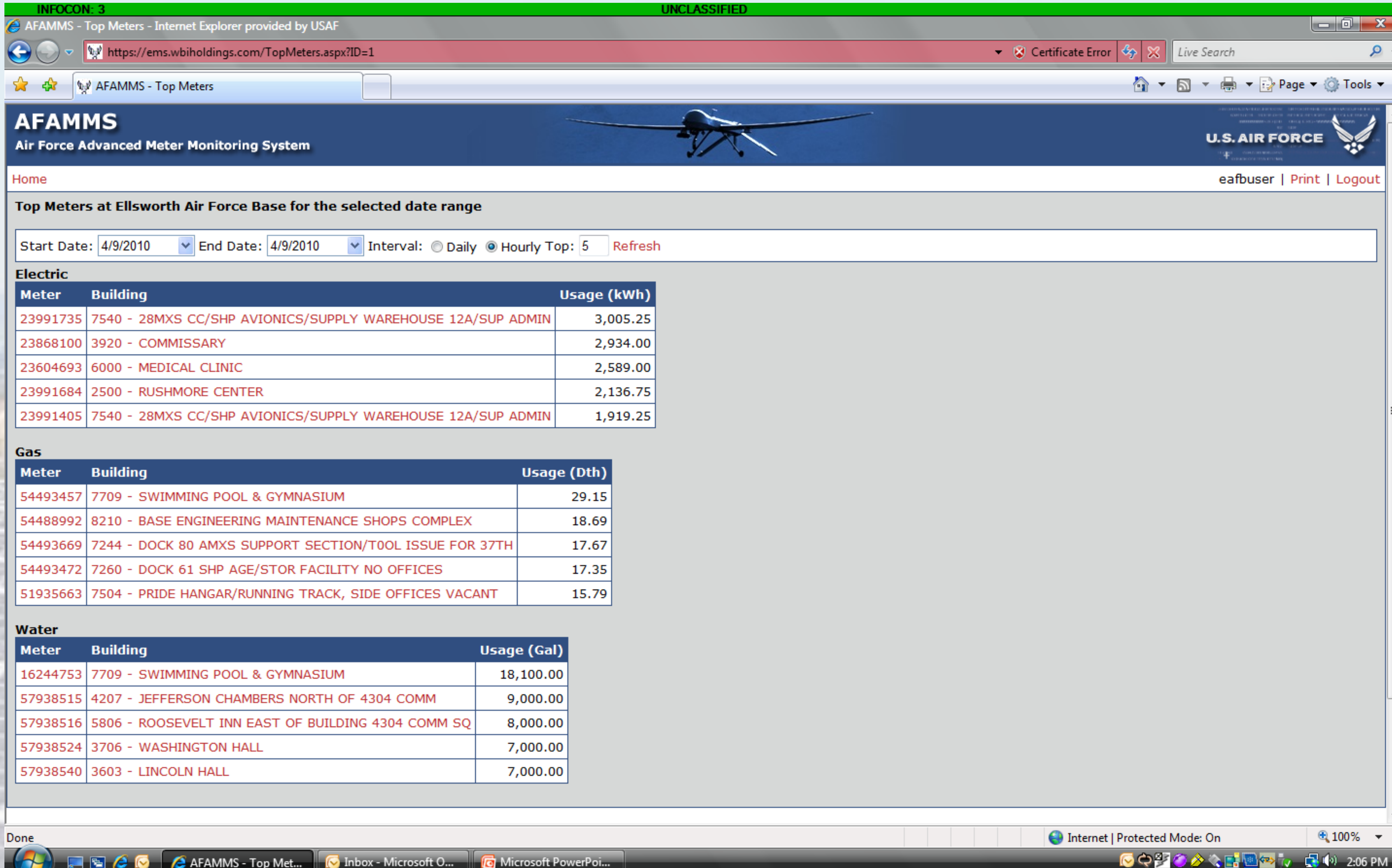


Renewable Energy



Blue Bar = Previous FY Yellow Bar = Current FY Green Bar = Current FY Goal

Advanced Metering Website



INFOCON: 3 UNCLASSIFIED

AFAMMS - Top Meters - Internet Explorer provided by USAF

https://ems.wbiholdings.com/TopMeters.aspx?ID=1

AFAMMS

Air Force Advanced Meter Monitoring System

U.S. AIR FORCE

Home | eafbuser | Print | Logout

Top Meters at Ellsworth Air Force Base for the selected date range

Start Date: 4/9/2010 End Date: 4/9/2010 Interval: Daily Hourly Top: 5 Refresh

Electric

Meter	Building	Usage (kWh)
23991735	7540 - 28MXS CC/SHP AVIONICS/SUPPLY WAREHOUSE 12A/SUP ADMIN	3,005.25
23868100	3920 - COMMISSARY	2,934.00
23604693	6000 - MEDICAL CLINIC	2,589.00
23991684	2500 - RUSHMORE CENTER	2,136.75
23991405	7540 - 28MXS CC/SHP AVIONICS/SUPPLY WAREHOUSE 12A/SUP ADMIN	1,919.25

Gas

Meter	Building	Usage (Dth)
54493457	7709 - SWIMMING POOL & GYMNASIUM	29.15
54488992	8210 - BASE ENGINEERING MAINTENANCE SHOPS COMPLEX	18.69
54493669	7244 - DOCK 80 AMXS SUPPORT SECTION/TOOL ISSUE FOR 37TH	17.67
54493472	7260 - DOCK 61 SHP AGE/STOR FACILITY NO OFFICES	17.35
51935663	7504 - PRIDE HANGAR/RUNNING TRACK, SIDE OFFICES VACANT	15.79

Water

Meter	Building	Usage (Gal)
16244753	7709 - SWIMMING POOL & GYMNASIUM	18,100.00
57938515	4207 - JEFFERSON CHAMBERS NORTH OF 4304 COMM	9,000.00
57938516	5806 - ROOSEVELT INN EAST OF BUILDING 4304 COMM SQ	8,000.00
57938524	3706 - WASHINGTON HALL	7,000.00
57938540	3603 - LINCOLN HALL	7,000.00

Top 10 Gas Meters – Annual

DOD Agency USAF Utility Rate - $8.56943/Dth

Building	Consumption	Cost
B 7504 Pride Hangar	13,396.23 Dth.	$114,798
B 7709 Pool & Gymnasium	13,382.33 Dth.	$114,678
B 7262 Dock 60 AGE Service	11,927.25 Dth.	$102,209
B 7260 Dock 61 SHP AGE Storage	10,299.01 Dth.	$ 88,256
B 7244 Dock 80 AMXS Support	8,209.00 Dth.	$ 70,346
B 7239 Dock 83	8,031.50 Dth.	$ 68,825
B 8210 Base Engineering Shops	7,605.33 Dth.	$ 65,173
B 7240Dock 82 MUN AGE	7,128.97 Dth.	$ 61,091
B 2500 Rushmore Center	6,962.00 Dth.	$ 59,660
B 7618 Dock 31 28AMMXS	6,921.51 Dth.	$ 59,313

Air Force Energy Vision

- Reduce demand through conservation
- Increase alternative energy sources
- Consider energy impact in everything we do
- Achieve goals and mandates
- Advance energy independence
- Leverage technology
- Foster Energy Development
- Match system reliability with asset security
- Enhance mission capability

A New Energy Technology Partner*

Bitter Creek Energy Services

Ellsworth Air Force Base

**South Dakota School of Mines and Technology*

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The People

- Mr. Chuck Miller, Bitter Creek Energy Services
  - Energy Manager
  - UESC Contractor EAFB and Minot AFB
  - Part of MDU Resource Group
- Mr. Dell Petersen, Civ USAF ACC 28 CES/CEAOU
  - Energy Manager
- Ms. Lisa Teeslink, Tetra Tech, REM, EAFB
- Engineering Student Interns from SDSMT
- Mr. Dale “Butch” Skillman, PE
  - SDSMT Research Engr., Dir. Office of Tech Transfer

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The Projects

- SDSM&T Senior Design Project Sponsorship
  - Bitter Creek Energy Services $25K
  - Four Types of Flat Plate Solar Collectors
    - Photovoltaic
    - Straight Thermal
    - Hybrids I and II
- BAA – AFRL (Proposed - $400K)
  - Full sized Building Integrated (BI) Collectors
  - BOS to include Organic Power Cycle & Heat Pump
    - (BOS = Balance of System)

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Four Functional Solar Arrays, SDSMT
Sr. ME Design Project 2009-2010

Nellis AFB PV Array

- Designed to provide 25 million kWh annually
- Direct use, no storage

Solar Thermal

- Where’s the Heat?

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EAFB knows where the heat goes!

- Which building/system/process uses the most thermal energy at your facility? (Metering)
- Which demands may be met through a direct use of solar thermal? (System Inventory to Characterize Thermal Loads)
- What type of solar thermal best meets your needs? (Application Design)
- What energy performance/design algorithm best models your system? (Does it model the Thermal System you would like to specify?)
- How do you verify your energy savings once the Solar Thermal System is on and operating? (Monitor)

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Types of **Solar Thermal** Collectors

- Transpired Collectors (with or without glazing)
  - Low Temperature rise
  - Ventilation Air Preheating
  - Relatively High Efficiency – 70+%
- Flat Plate Collectors (with Glazing)
  - Medium Temp Rise
  - Space Heating
  - Reasonable Efficiency – 60%
- Note: Solar Thermal raises the temp of a fluid.

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Transpired Solar Collector

- Pre-heating of Make-up Air

Transpired SolarWall – Fort Drum

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In The Beginning – circa 1977

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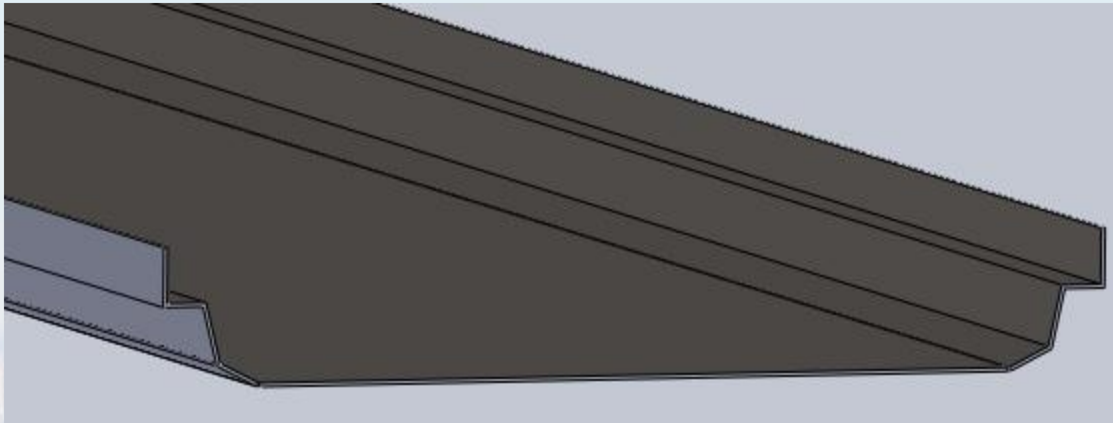
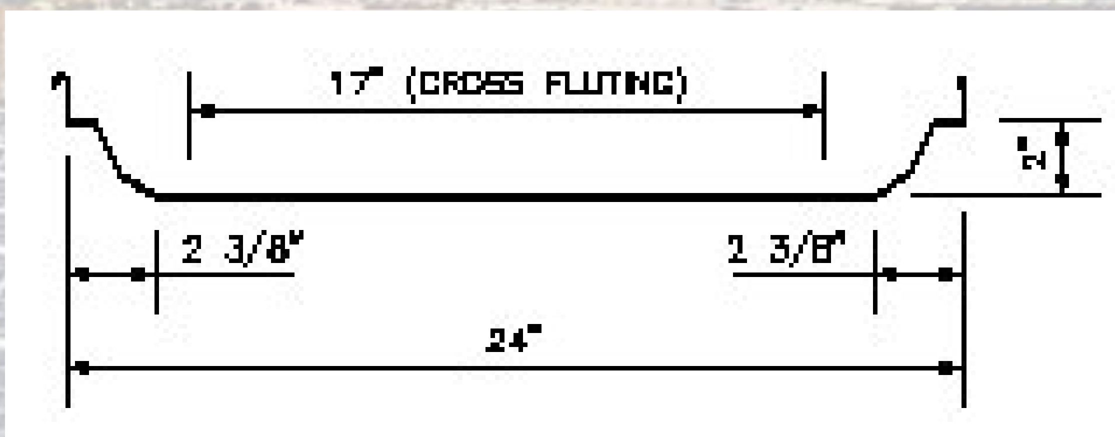
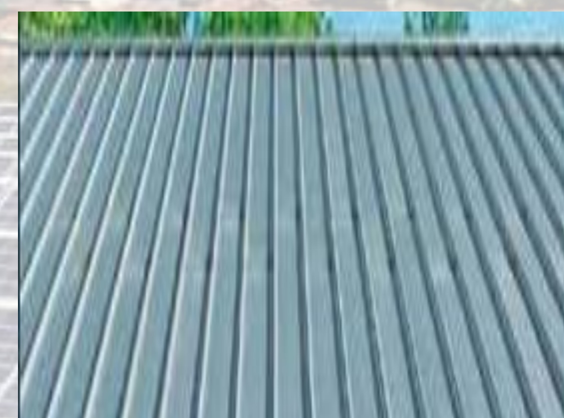
Building Integrated Solar

- Suitable for New and retrofit construction
- Solar Collector integrated into the building envelope.
- Typically a Lower First Cost
- Aesthetic Appeal
- Job-Site Fabrication

The MR-24 Metal Panel







http://www.butlermfg.com/architects/downloads/manual/Design%20Specifiers%20Manual%2001-27-08.pdf

Early Solar Design and Modeling

- NREL was SERI with Denis Hayes as its first Director
- Amory Lovins was on “Soft Energy Paths”
- Mid-America Solar Energy Complex - Operational
- John A. Duffie, William Beckman, S.A. Klien
  - These are the true fathers solar thermal design and modeling. TRNSYS and FChart in the Mid-70’s.
  - PV modeling w/TRNSYS not until mid 1980’s
- Currently hundreds of Solar Algorithms – very few address solar thermal, fewer address Hybrid PVT

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Current Thinking PVT– circa 2010

Hybrid Solar - PVT

- Very Widely used in Europe
- Collectors have Both Electric and Thermal Outputs
- Cooling the PV Array increases the PV Efficiency
- Hybrid Solar Collector Efficiency 65%+

PVT Demo at EAFB

- Free Standing Solar Structure near EAFB PAMP
- 1000-1200 Square Feet of BIPVT
  - Standing Seam Metal Roof Platform
  - Half of roof Area = Liquid Type Flat Plate
  - Half of roof Area = Air Type Flat Plate
  - 1/3 glazed with Poly Crystalline Module (Hybrid)
  - 2/3 Glazed with Low Iron double glass glazing
- Designed utilizing TRNSYS
- Instrumented for performance assessment.

Insuring Energy Project Successes

- Characterize loads thru metering
- Use Solar Thermal whenever you can
- Select applications with the most potential
- Design utilizing predictive dynamic models
- Monitor performance thru metering

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Questions

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